

- 3) Discrete semi-conductors (Circa, 1960)
- 4) Integrated circuits (Circa 1965)
- 5) Direct-numerical control (Circa, 1964)
- 6) Computer numerical control (Circa, 1970)
- 7) Micro-processors & micro-computers (Circa, 1975)

Vacuum tubes: - These components were so large that the control unit consumed more space than the m/c tool.

Electromechanical relays: - These were substituted for vacuum tubes. The problem with these relay-based controls was their large size and poor reliability. The relays were susceptible to wear.

The use of transistors based on discrete semiconductor technology formed the next generation of NC controllers. The use of transistors helped to reduce the no. of electromechanical relays required.

Size & reliability still remained as problems with NC controls which used discrete semi-conductors. The electronics were sensitive to heat, & fans or A/Cs were required in the cabinets to operate under factory conditions. Thus, integrated circuits were introduced for use in NC controls. This type of electronic hardware brought significant improvements in size & reliability.

The next development in NC control marked the introduction of digital computers in NC controller technology. All of the previous controls were made up of hard-wired components. The functions that were performed by these control systems could not be easily changed due to the fixed nature of the hard-wired design.

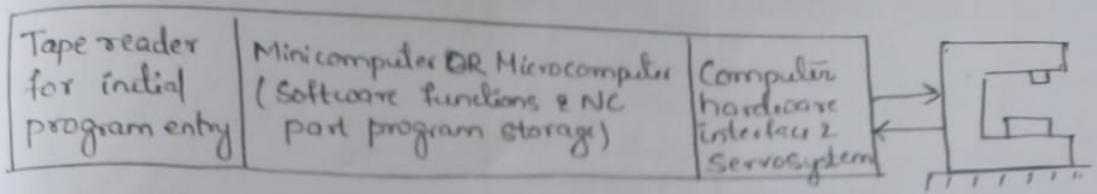
- DNC was the 1st computer control systems to be introduced in 1968. Computers were quite large & expensive. The advantage of DNC was it established a direct control link bet<sup>n</sup> the computer & the m/c tool, hence eliminating the necessity for using punched tape input.

(The tape & tape reader most unreliable components in conventional NC systems)

- Demand for smaller & less expensive computers, led to apply a single small computer to one m/c tool, led to the development of CNC. CNC systems they applied the soft-wired controller approach.

### Computer Numerical Control

- CNC is an NC system that utilizes a ~~d~~ stored program computer to perform some or all of the basic numerical control functions.
- Because of the trend toward downsizing in computers, most of the CNC systems use a micro-computer based controller unit.
- Punched tape readers are still the common device to input the part program into the system. With conventional NC, the punched tape is cycled through the reader for every workpiece in the batch. With CNC, the program is entered once & then stored in the computer memory. Thus, the tape reader is used only for the original loading of the part program and data.
- CNC offers additional flexibility & computational capability.



## General Configuration of CNC System

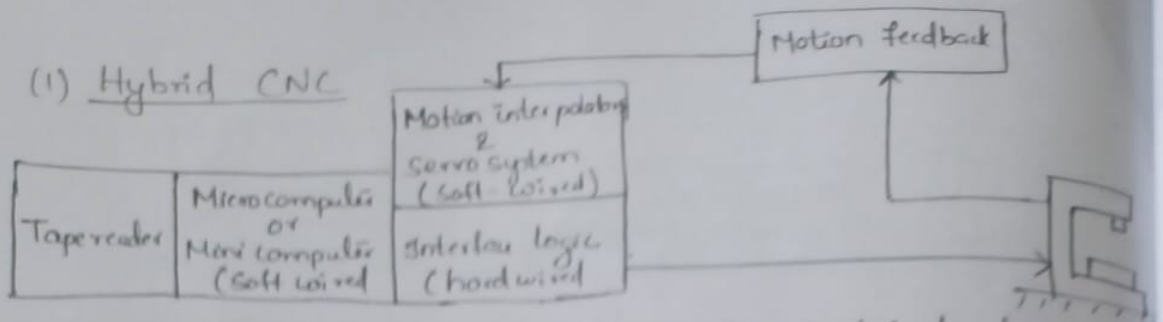
### Functions of CNC

- (1) M/c tool control
- (2) In-process compensation
- (3) Improved programming & operating features
- (4) Diagnostics

### M/c tool control :-

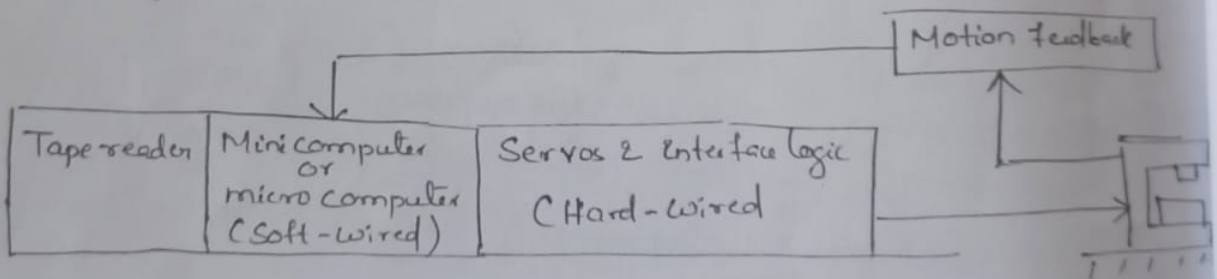
- The primary function of the CNC system is control of the m/c tool. It involves conversion of the part program instructions into m/c tool motions through the computer interface and servosystem.
- Main advantage of CNC :- to conveniently incorporate a variety of control features into the soft-wired controller unit.
- Some of the control functions (such as circular interpolation) can be done more efficiently with hard-wired circuits than with the computer.
- This led to development of two alternative controller designs in CNC:

- (1) Hybrid CNC
- (2) Straight CNC



- The controller consists of the soft-wired & hard-wired logic circuits.
- The hard-wired components perform those functions, which they do best (feed rate generation, circular interpolation).
- The computer performs the remaining control functions and other duties, not normally associated with a conventional hard-wired controller.
- Certain NC functions can be performed more efficiently with the hard-wired circuits. Therefore, the circuits that perform these functions can be produced in large quantities at relatively low cost. Hence, a less expensive computer is required in the hybrid CNC Controller.

### Straight CNC:-



- The Straight CNC System uses a computer to perform all the NC functions. The only hard-wired elements are those required to interface the computer with the machine tool & operator's console.
- Interpolation, tool position feedback and all other functions are performed by computer software.



- ④
- The advantage gained in straight CNC is additional flexibility.

### IN-PROCESS COMPENSATION

- A fun<sup>n</sup> closely related to m/c tool control is in-process compensation.

- Ex. - Adaptive control adjustments to speed/feed.
- Adjustment for errors sensed by in-process inspection probes & gauges.

### IMPROVED PROGRAMMING AND OPERATING FEATURES

- The flexibility of soft-wired control has led to many convenient programming & operating features, such as:
  - (1) Editing the part programs at the m/c.
  - (2) Manual data input (MDI).
  - (3) Local storage of more than one part program.
  - (4) Graphic display of tool path.

### DIAGNOSTICS

- NC m/c tools are complex & expensive systems. The complexity increases the risk of component failures which lead to system downtime.
- CNC machines are equipped with a diagnostics capability to assist in maintaining & repairing the system.

## Advantages of CNC

- (1) The part program tape & tape reader are used only once to enter the program into computer memory. (Tape)
- (2) Tape editing at the m/c site:-  
(change of tool path, speeds & feeds) at the side of m/c tool.
- (3) Metric conversion:- CNC can accommodate conversion tapes prepared in units of inches into the International System of units.
- (4) Greater Flexibility:-  
provides opportunity to introduce new control options with relative ease at low cost.

(5)

## Direct Numerical Control

- Manufacturing system in which a no. of machines are controlled by a computer through direct connection in real time.
- The tape reader is omitted in DNC, thus relieving the system of its least reliable component.
- The part program is transmitted to the m/c tool directly from the computer memory.
- The DNC computer is designed to provide instructions to each m/c tool on demand. DNC also involves data collection & processing from the m/c tool back to the computer.